8000 Training Manual 651

FLUKE 8000A DIGITAL MULTIMETER

FLUKE 8000A DIGITAL MULTIMETER

FLUKE 8000A DIGITAL MULTIMETER

STUDENT HANDOUT

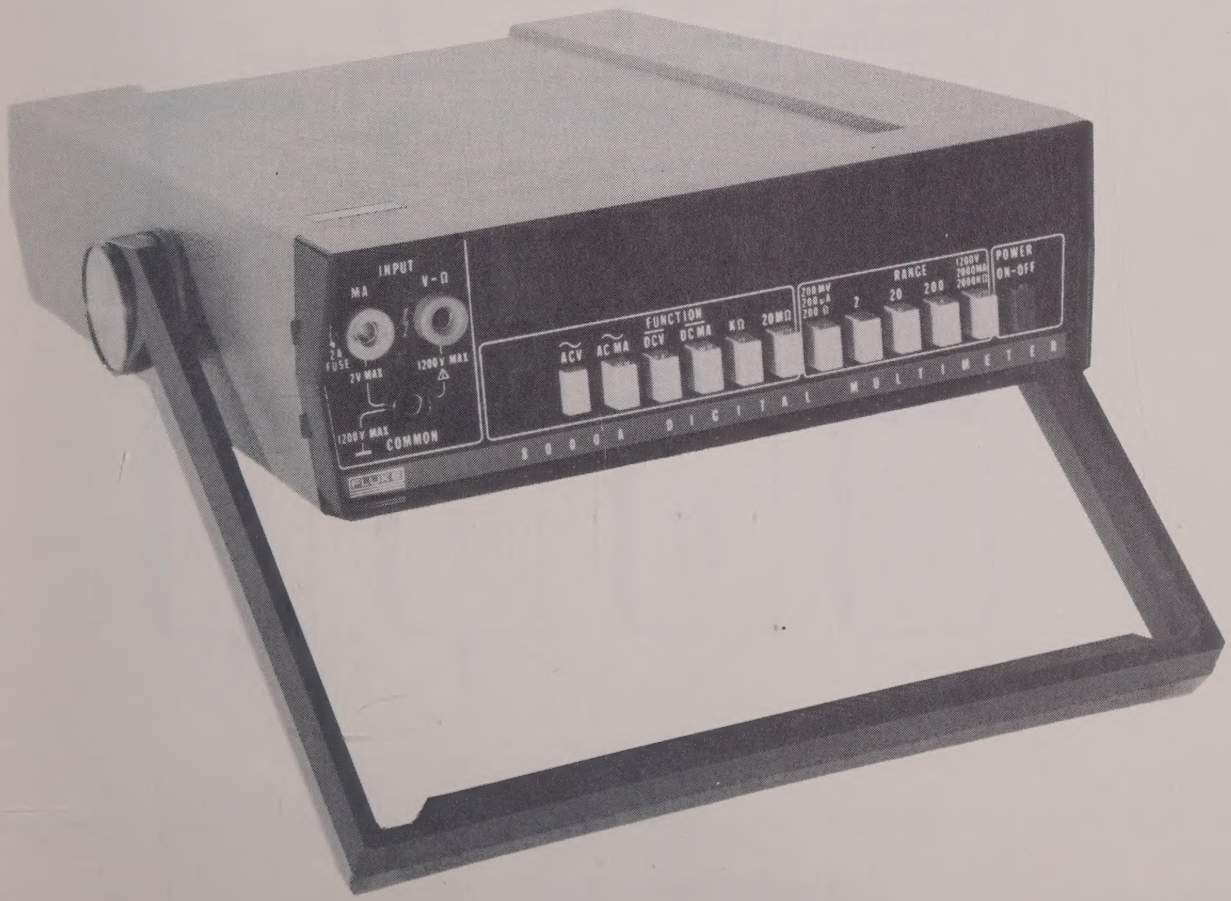
FLUKE®

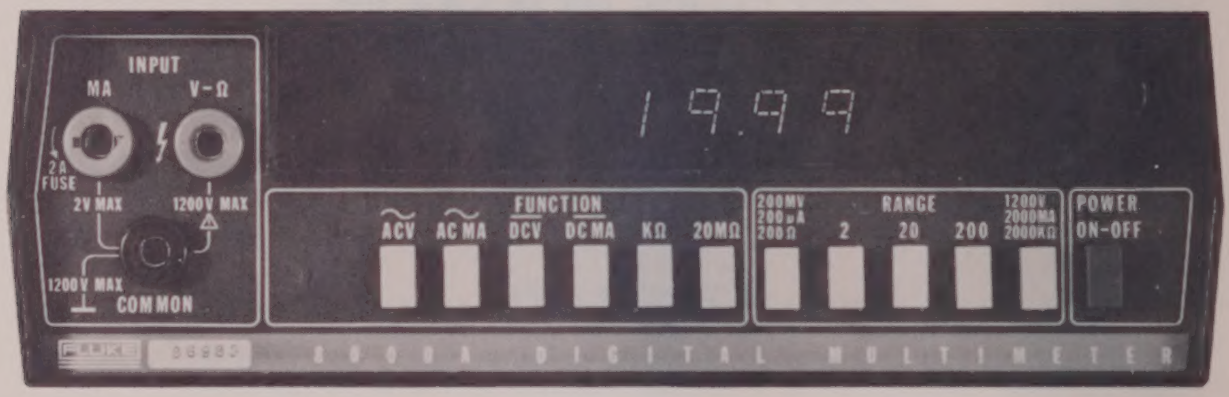
Customer Service Training Department

JOHN FLUKE MFG. CO., INC.
P.O. BOX 43210 MOUNTLAKE TERRACE, WA 98043
TEL: (206) 774-2409

Foreword

This training course has been prepared by the Customer Service Department of the John Fluke Mfg. Co., Inc. to assist the experienced technician to understand how the instrument works, how to calibrate it and how to maintain it. Should you have any questions, comments or suggestions about this course of instruction please feel free to communicate them to the Training Department by letter or telephone.





INTRODUCTION

The model 8000A multimeter allows, through push-button controls, the selection of five ac and dc voltage ranges, five ac and dc current ranges, and six resistance ranges. Measurement capabilities range from 100 μV to 1199V ac and dc, 100 nA to 1.999A, and 100 MΩ to 19.99 MΩ.

It is the purpose of this workbook to present the reader with enough information about the theory of operation and methods of repair to make it possible for them to efficiently maintain, calibrate, and repair the 8000A. This manual was intended to supplement the audio-visual training program on the 8000A multimeter.

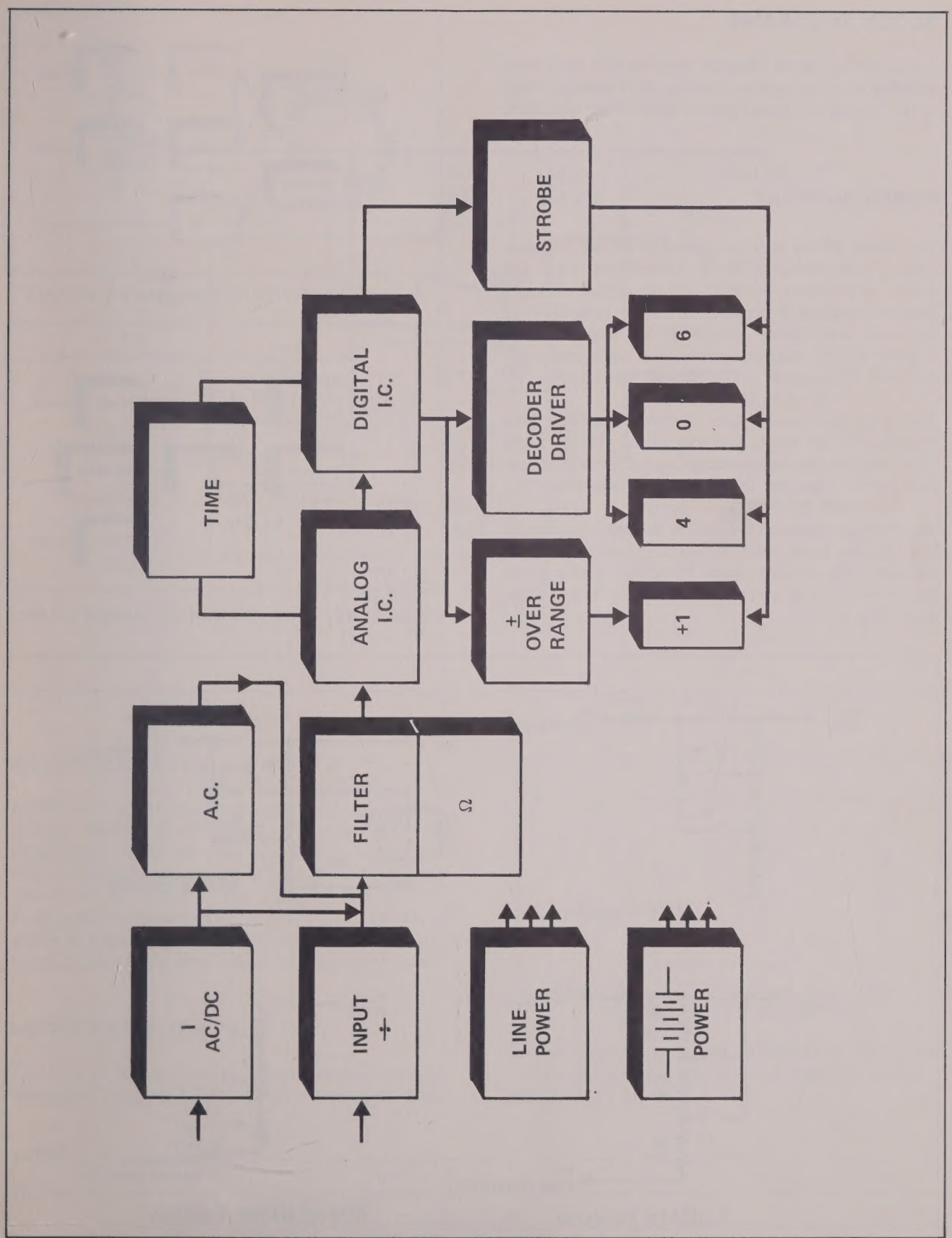


Figure 1. FULL BLOCK DIAGRAM

BLOCK DIAGRAMS

The following block diagram descriptions have been included in order to give a fundamental understanding of the various functional circuits within the instrument.

POWER SUPPLIES

The model 8000A uses two different Power Supplies. One, a Line Operated Power Supply used when the battery option is not included with the instrument and a Battery Operated Power Supply which is used when both line and battery operation are desired. These supplies are not interchangeable. The appropriate supply must be included in the original instrument.

The Line Operated Power Supply furnishes three voltages for use within the instrument +15 volts and -15V used as operating voltages and a +5 volts that is used for the logic and I.C. Display Circuits. (Fig. 2)

The Battery Operated Supply is designed to operate from the line power while recharging the self-contained batteries. The output voltages furnished by this power supply are +15 volts and -15 volts and a +5 volts for the logic. (Fig. 3)

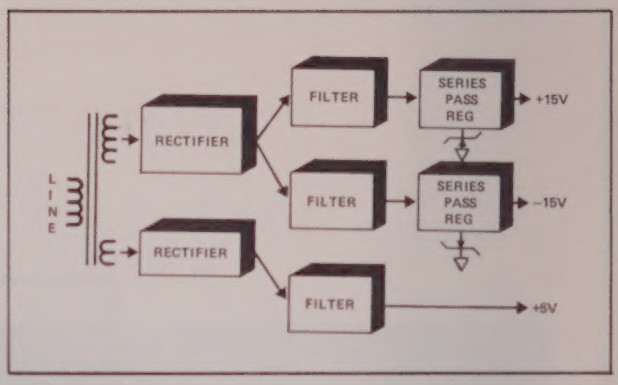


Figure 2. LINE OPERATED POWER SUPPLY

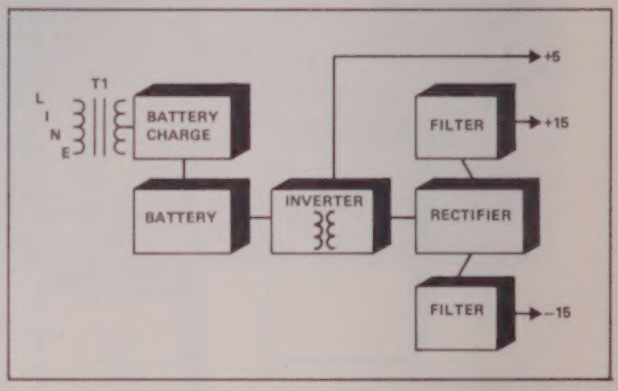


Figure 3. BATTERY OPERATED POWER SUPPLY

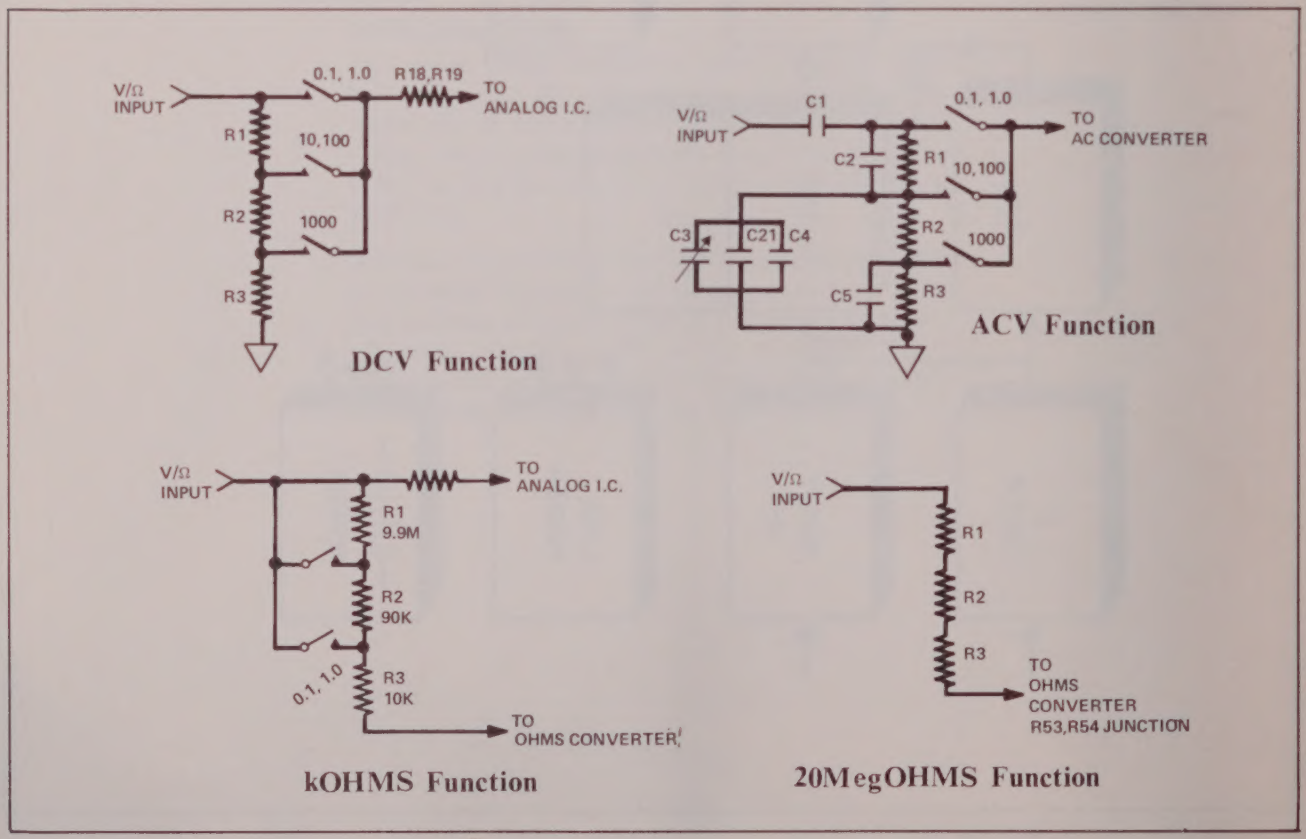


Figure 4. INPUT DIVIDER (4 CONFIGURATIONS)

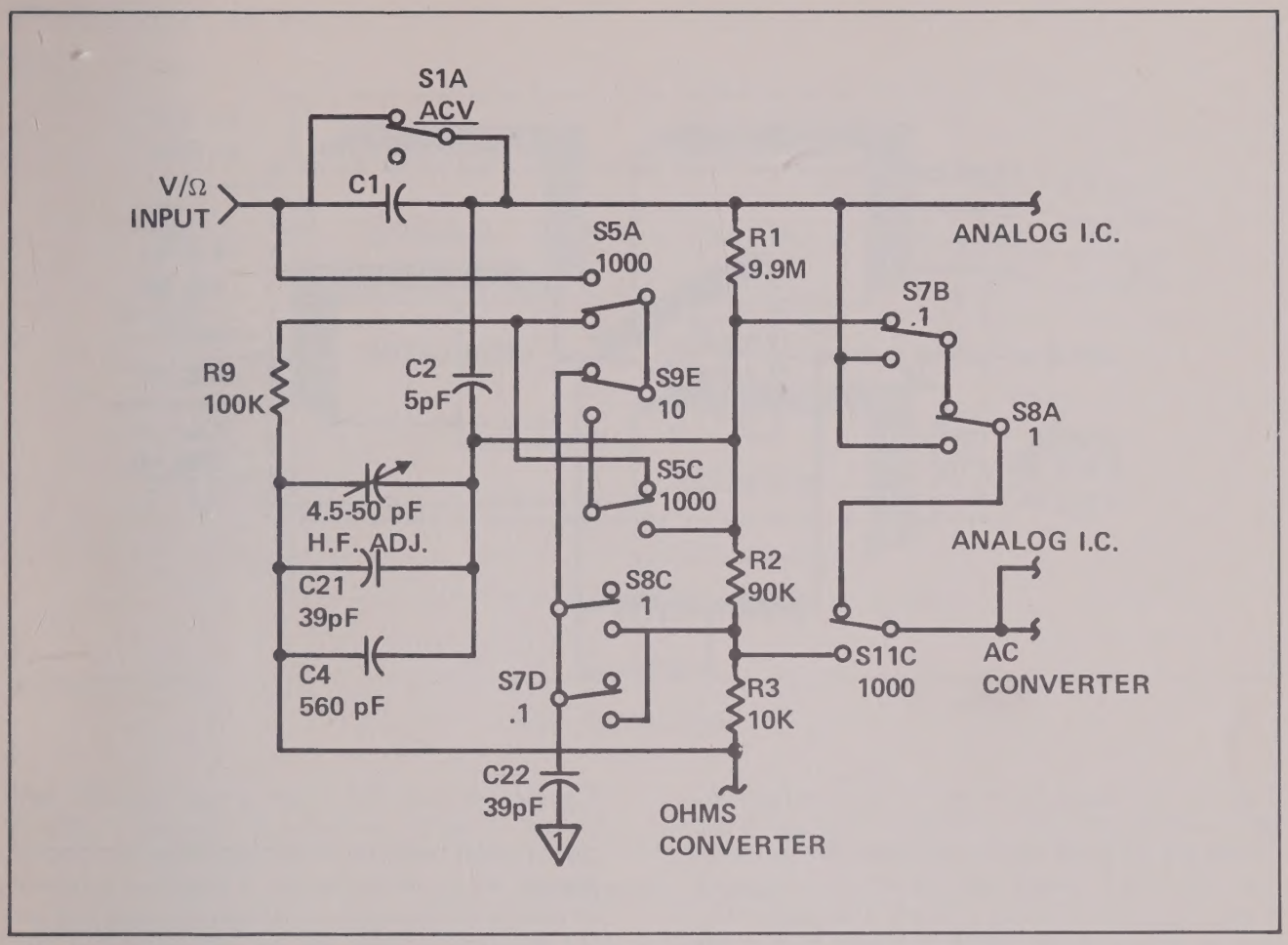


Figure 5. INPUT DIVIDER

INPUT DIVIDER (Fig. 4 & 5)

As seen in Figure 1, the first block is the Input Divider. It is the function of this circuit to attenuate the input signal to one of the two basic ranges of the instrument. The two basic ranges of the instrument are 0 to ±0.2 volts and 0 to ±2 volts. The Input Divider has four configurations depending upon the function selected, as shown in Figure 4. The attenuated voltage out of the Input Divider is fed directly to the Active Filter circuit.

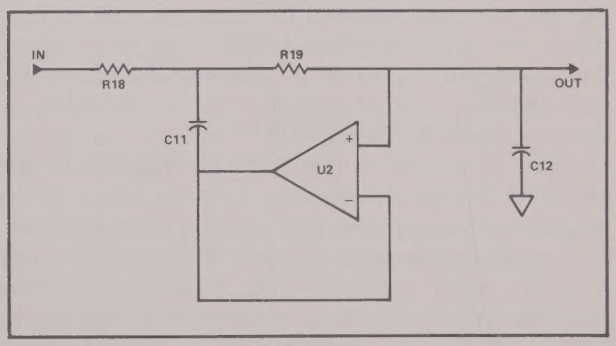


Figure 6. ACTIVE FILTER

ACTIVE FILTER (Fig. 6)

The Active Filter is a two pole filter designed around a Monolithic Integrated Circuit. It is the purpose of the Active Filter to eliminate noise components that appear on the measurement line before the signal is presented to the Analog I.C.

NOTES:

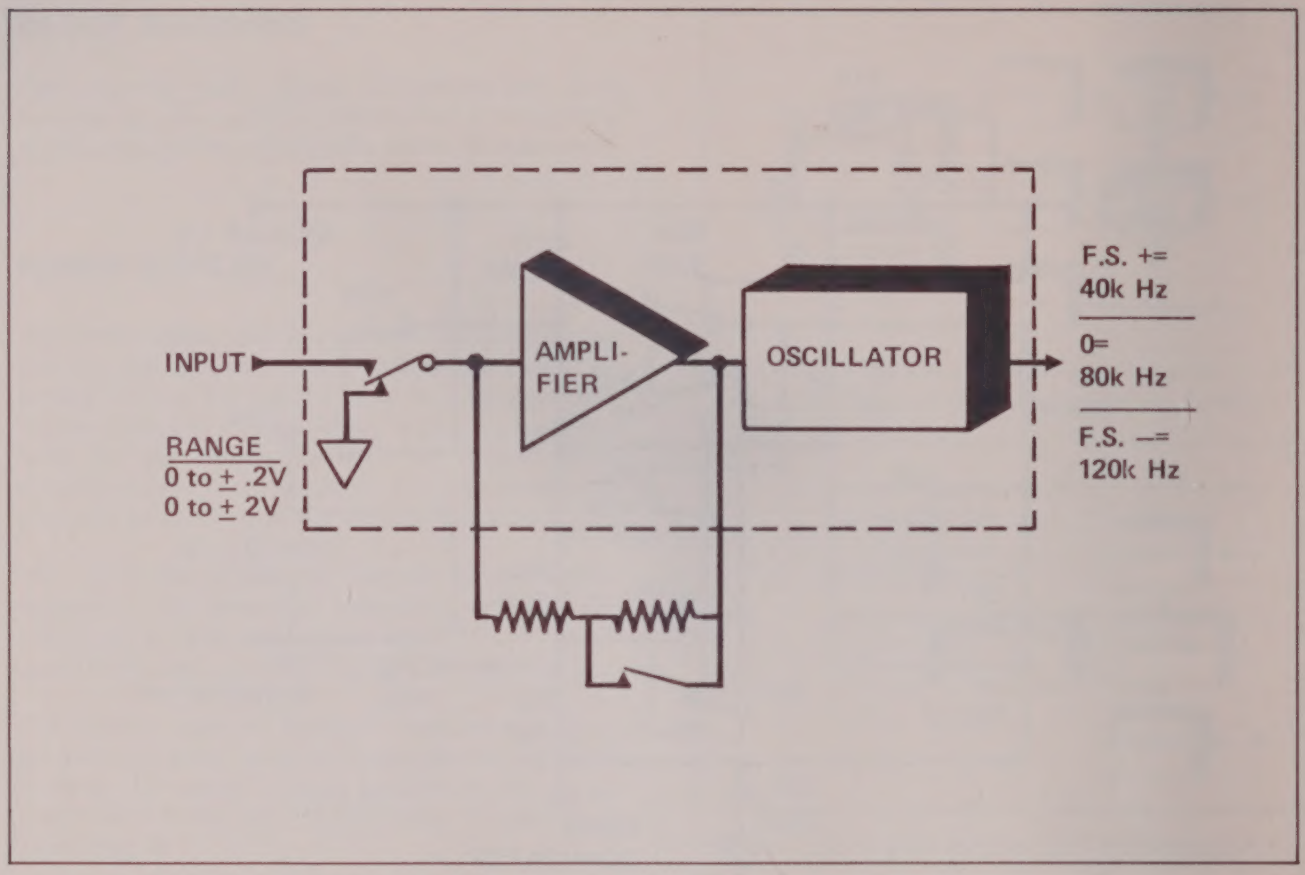


Figure 7. ANALOG I.C.

ANALOG I.C. (Fig. 7)

The input to the Analog I.C. is always a dc voltage within one of the two basic ranges of the instruments. The Analog I.C. contains an electronic switch, a dual gain amplifier, and an oscillator and is configured as shown in Figure 4. During ZERO Time, the input to the amplifier is shorted so that 0 volts is supplied to the amplifier. During Measurement Time the voltage to be measured to the instrument is connected to the amplifier. This results in two different inputs being applied to the amplifier under control of the timing circuit. The amplifier feeds an oscillator whose output frequency is determined by the magnitude of the voltage being applied to the amplifier. With 0 volts applied to the amplifier, the oscillator will oscillate at a frequency of 80 kHz. A positive polarity voltage will cause the oscillator frequency to change downward to a maximum deviation of 40 kHz. A negative voltage input to the amplifier will cause the output frequency of the oscillator to range from 80 kHz at 0 volts to 120 kHz at maximum input. The actual frequency of the oscillator is determined by the analog value applied to the Analog I.C. A full scale positive voltage +2 volts or +0.2 volts, depending upon the input range of the instrument, will cause the output frequency to increase to a maximum of 120 kHz.

DIGITAL I.C. (Fig. 8)

It is the purpose of the Digital I.C. to count the frequencies being applied from the Analog I.C., and to convert the difference count into Binary Coded Decimal format. Polarity Sensing information is derived from the input frequency as is Overrange information. Polarity and Overrange information is fed to the Polarity and Overrange circuitry, while the BCD count is applied to the Decoder Driver, and Strobing Pulses S1, S2, S3 and S4, generated in the Gating circuit of the Digital I.C., are fed to the Strobing Circuit.

To understand the operation of the Digital I.C., refer to Figures 8 and 9. During the ZERO Time, 100 ms, the Digital I.C. will count the nominal 80 kHz from the Analog I.C. During Measurement Time, with a full scale positive voltage, the output frequency of the Analog I.C. will be 40 kHz. The Digital I.C. will count and divide this frequency difference from 0 volts resulting in the BCD output representing 1999 counts. Should a maximum range negative voltage be applied to the instrument during Measurement Time the Digital I.C. will count 120 kHz from the Analog I.C. under those conditions; back down to its initial starting point and then back up once again producing a BCD count of 1999, but, since it had to count all the way to ZERO and

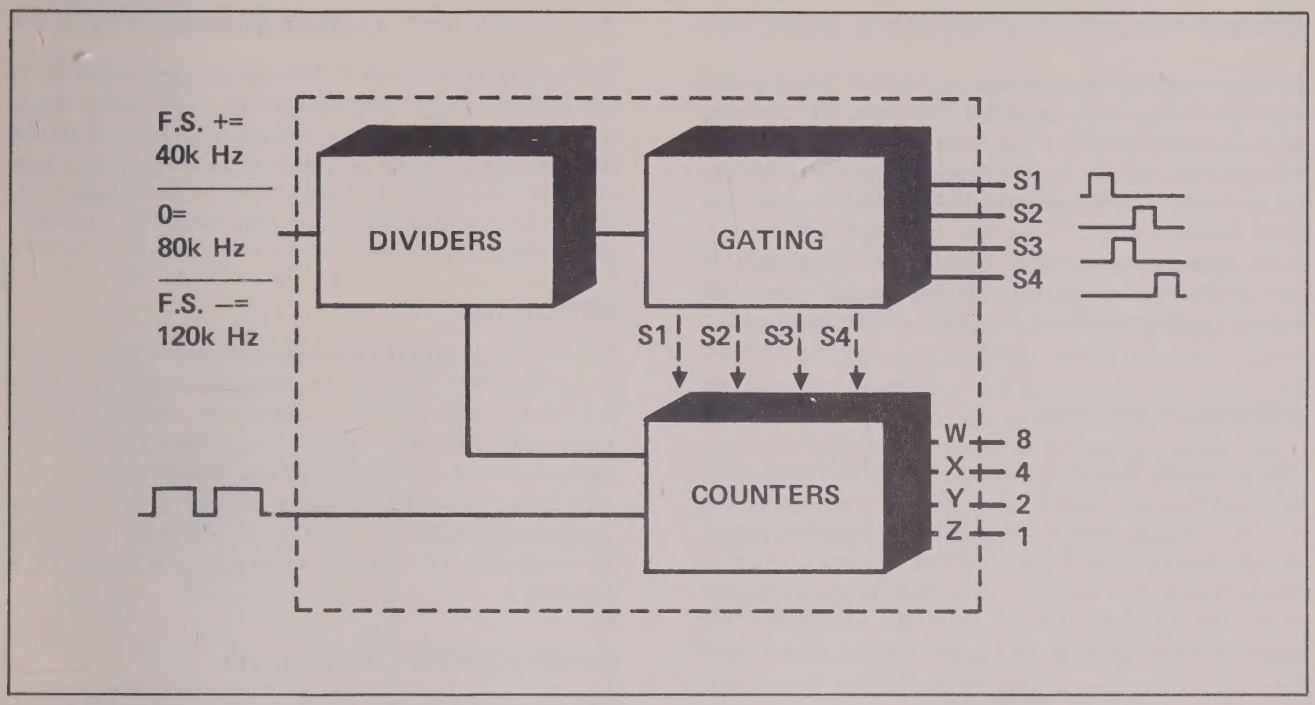


Figure 8. DIGITAL I.C.

then back up, the counters will have reversed and produce a negative output, thus sensing a negative polarity for use in the polarity and overranging circuit. Referring to Figure 8, the gating circuit will produce strobing pulses S1 through S4. These strobing pulses are used both externally and internally of the Digital I.C. Internally, the S1 pulse enables Polarity and Overrange information to be fed out of the Digital I.C. on the Y and Z lines to the Polarity and Overranging circuits. The S2 through S4 enable BCD count out of the Digital I.C. which is fed to the Decoder Driver. The Z line has a BCD weight of 1, the Y line a BCD weight of 2, and X line a BCD weight of 4, and the W line has a BCD weight of 8.

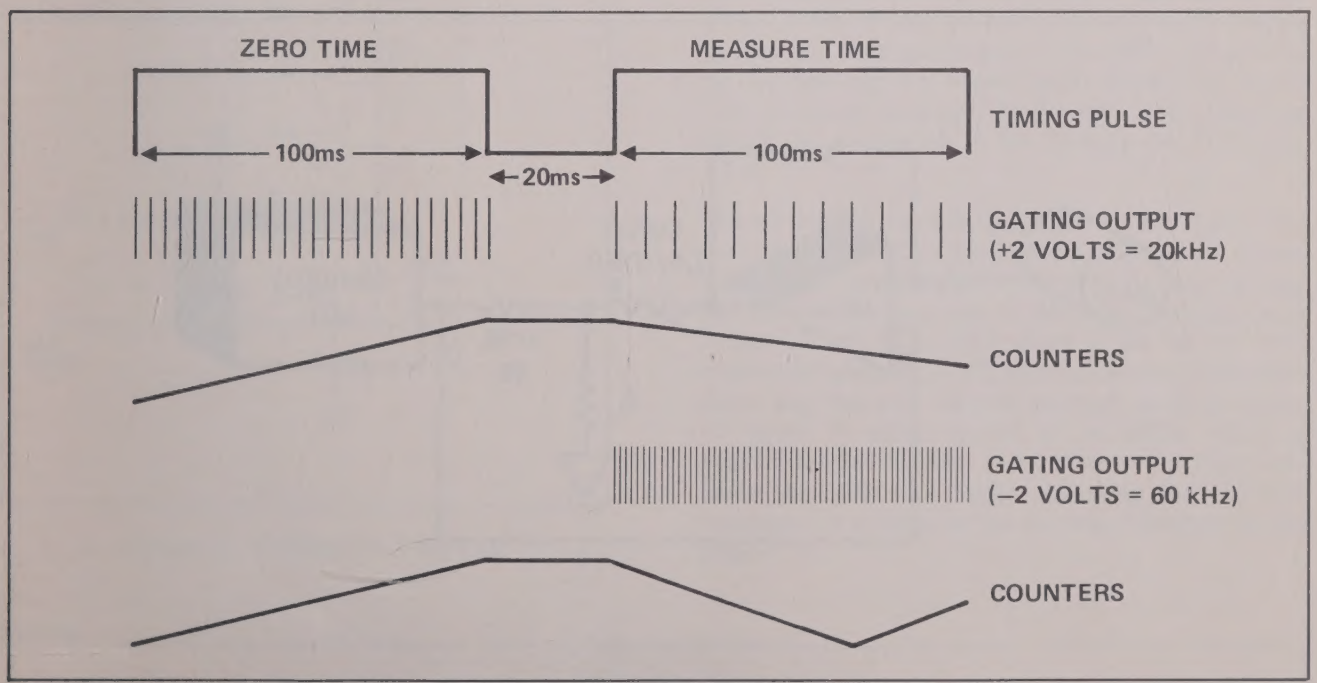


Figure 9. COUNT

TIMING CIRCUIT (Fig. 9)

The Timing Circuit generates two 100 ms timing pulses separated by a 20 ms rest pulse. The first 100 ms timing pulse is called ZERO Time, which causes the input to the Analog I.C. to be shorted, leaving its output to arrive at the rest frequency of 80 kHz. The 20 ms of rest time between ZERO Time and Measurement Time is used to allow the circuitry to stabilize. The second 100 ms pulse is Measurement Time, during which the voltage to be measured is applied to the Analog I.C.

DECODER DRIVER

The Decoder Driver translates the BCD count, generated within the Digital I.C., into decimal format that will combine in such a manner as to light the appropriate sections of the Light Emitting Diodes, in order to display the proper number. The potential on these lines from the Decoder Driver becomes low when the numeral information is being commanded. (See Figure 1.)

LIGHT EMITTING DIODES (LED'S)

In order to display a number, two conditions within the LED's must be present, simltaneously. These two conditions are a low level potential (0 volts) on the cathode of the LED's and a high potential (+5 volts) on the anode of the LED's. The low potential is supplied by the Decoder Driver and the high potential commanding them ON is furnished by the Strobing Circuit. (See Figure 1.)

POLARITY AND OVERRANGING

Polarity and Overranging information is supplied from the Digital I.C. on two of the four BCD output lines, prior to the presentation of the discreet count. It is the purpose of this circuit to enable the Overranging LED, when commanded, to display both the Overrange digit and Polarity information, as required in dc measurements. (See Figure 1.)

STROBING

It is the purpose of the Strobing circuitry to apply a high logic level (+5 volts), in the designed sequence, to the LED's to allow them to illuminate. These strobing pulses are generated within the Digital I.C. and are applied to the Strobing Circuit. When input to the instrument exceeds its design capacity, the strobing circuit will cause the LED's to blink to warn the operator that he is overloading the instrument. (See Figure 1.)

OHMS CONVERTER (Fig. 10)

When one of the resistance function switches is depressed, the Active Filter circuit serves two purposes, one, as an active filter and the other as an ohms converter amplifier. In the ohms functions the Active Filter is still used to reduce random noise on the signal line, the Ohms Converter operates in conjunction with the Input Divider and the unknown resistance, connected to the input terminals, to convert that resistance into a dc voltage that is within the basic range of the instrument. This output is fed through the Active Filter which outputs to the Analog I.C.

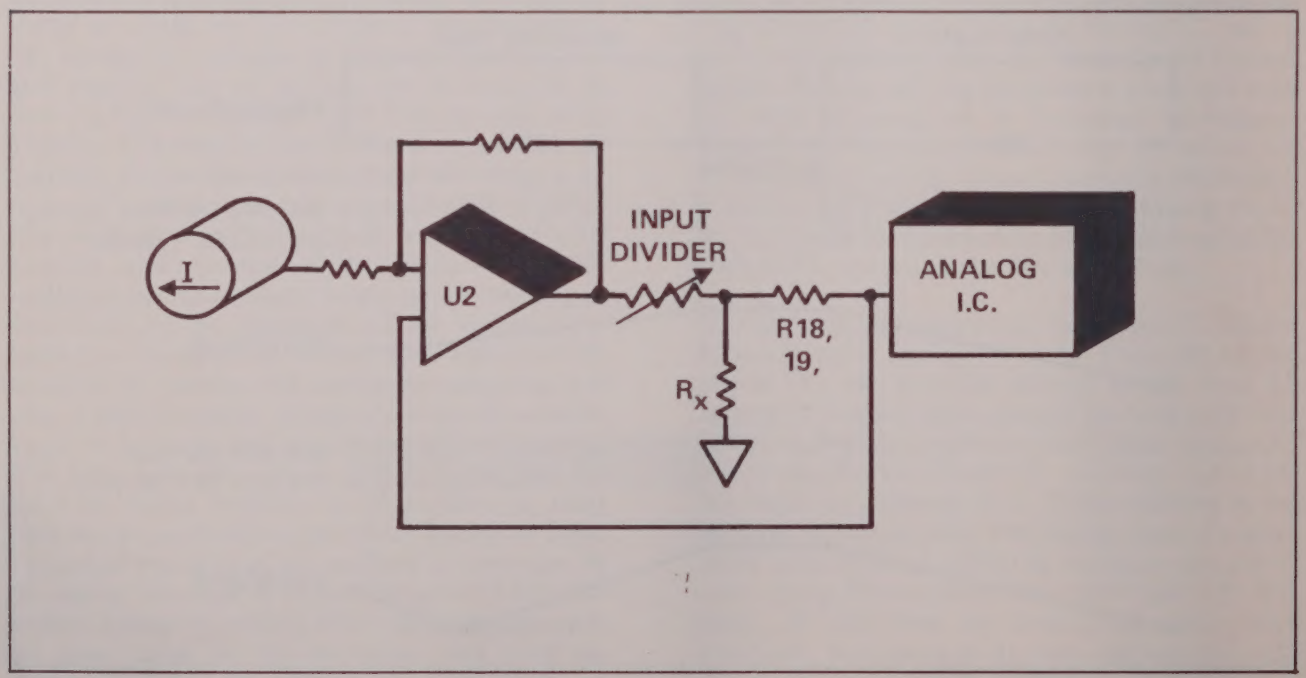


Figure 10. OHMS CONVERTER

AC CONVERTER (Fig. 11)

In all ac voltage functions, the ac voltage out of the input divider or current shunts is applied to the ac converter which will convert the ac voltage to dc voltage that is within one of the two basic ranges of the instrument.

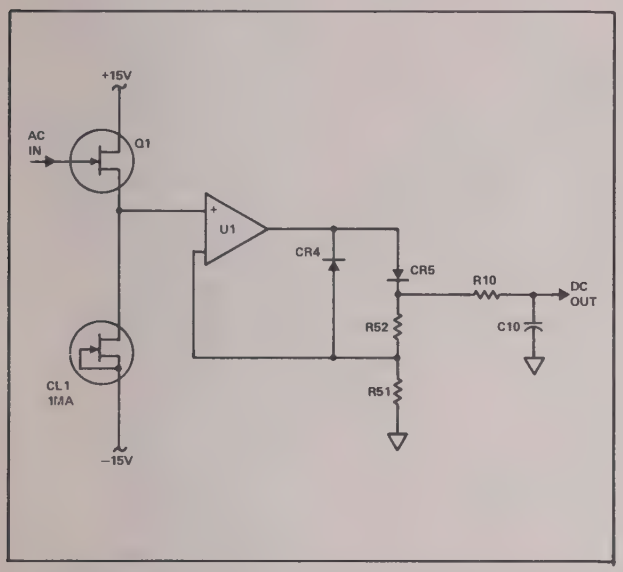


Figure 11. AC CONVERTER SIMPLIFIED DIAGRAM

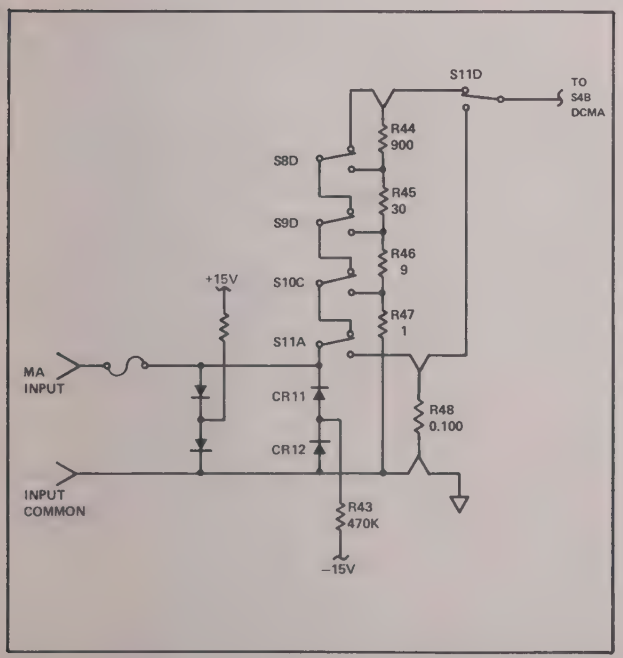


Figure 12. CURRENT SHUNTS

CURRENT SHUNTS (Fig. 12)

The Current Shunts are used to convert both ac and dc current inputs into ac or dc voltages that are within the basic ranges of the instrument. In the case of ac current inputs, the ac voltage output of the Current shunt is applied to the ac converter for conversion to dc voltage.

Protection for the Current Shunts is furnished by Fuse F2 and Diodes CR9, CR10, CR11, and CR12. The Current Shunts are Resistors R44 through R48. Notice that the R48 is a four terminal resistor in order to derive the accuracy required in the high current function. The current to be measured is applied to the Current Shunts and the resultant voltage drop across the current shunt is applied through Switch S11D to either the ac converter for ac mA function or to the Active Filter and into the Analog I.C. in the dc mA function.

SUMMARY

Input to the instrument is applied through the Input Attenuator and/or other input signal conditioners and applied to the Active Filter where undesirable noise is removed. The noise free dc voltage from the Active Filter is applied to the Analog I.C. where it is converted into a specific frequency. The ouput of the Analog I.C. is two specific frequencies, one representing shorted input, the other representing the magnitude of the voltage being measured.

The output of the Analog I.C. is applied to the Digital I.C. which counts up during the ZERO Time period and then counts down during the Measurement Time period. The result is a BCD count which is decoded by the Decoder Driver into a decimal format which is compatible with the requirements of the LED's. The polarity of the input signal is sensed by the Digital I.C. and is then processed through the Polarity and Overrange circuit for application to the Polarity and Overrange LED.

The strobing commands, generated in the Digital I.C., then condition each Light Emitting Diode in the proper sequence of illumination. It should be pointed out that the illumination sequence is DS1, the Overrange and Polarity LED. Then DS3 which is the second most significant figure, then DS2 which is the most significant figure and then DS4 which is the least significant figure of output. A signal applied to the 8000A which is beyond the instruments measurement capability will cause the LED's to blink, indicating the overload condition, as a result of the strobing furnished by the Digital I.C.

NOTES:

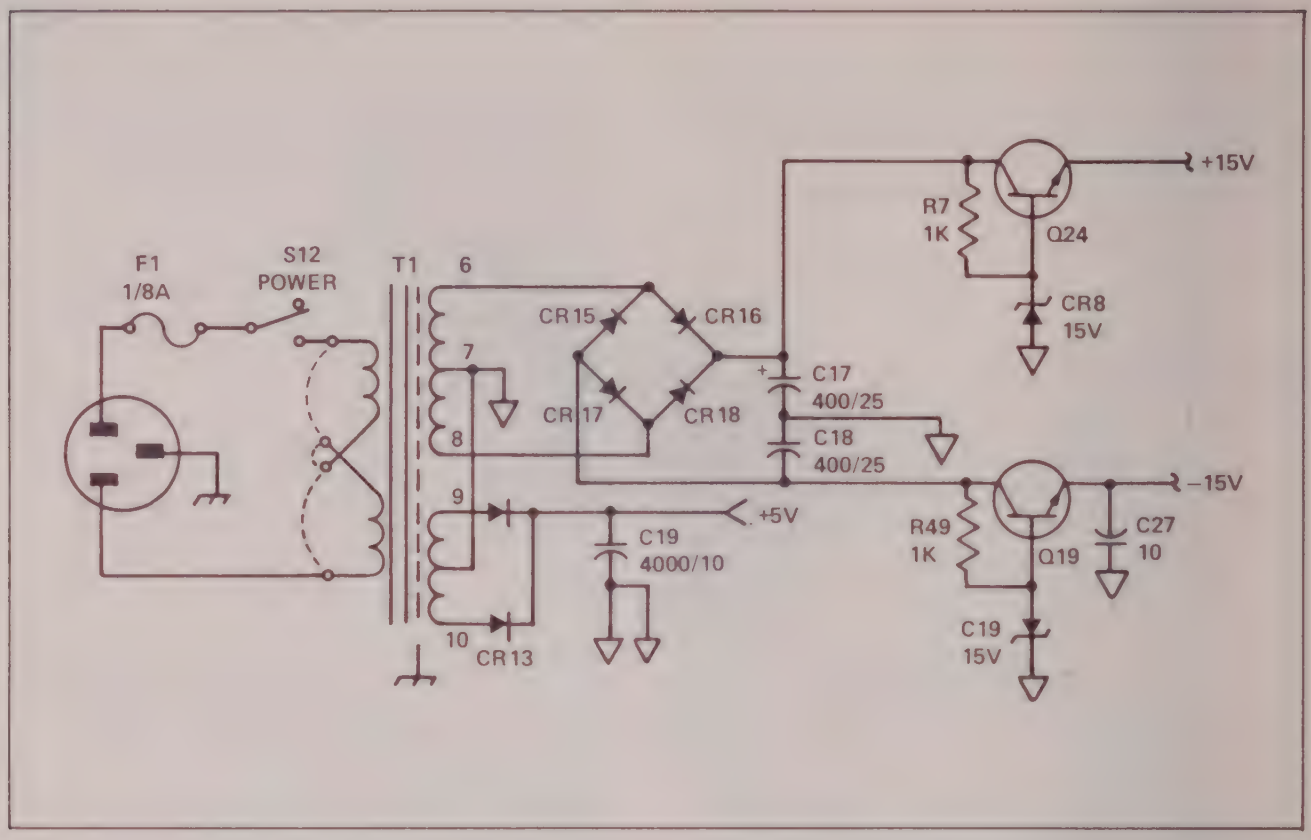


Figure 13. POWER SUPPLY LINE OPERATED

SCHEMATIC DIAGRAM DESCRIPTION

LINE OPERATED POWER SUPPLY (Fig. 13)

AC line power being applied to the primary of T1 develops a voltage across the secondary winding which is rectified by the bridge rectifier network CR15, CR16, CR17, and CR18. The positive output of that bridge rectifier appears across C17 and passes through Q24, which is a series pass regulator, referenced to a 15V zener diode, CR8, and results in the +15 volt supply. The negative output of that bridge rectifier is fed to C18 where it is filtered and then passed through Q19, which is also a series pass regulator, and referenced to a 15V zener diode CR19. A separate winding from T1 is connected to a full-wave rectifier, CR13 and CR14. Capacitor C19 acts as a filter and the result is a +5 volt supply used for the logic circuitry and light emitting diodes.

NOTES:

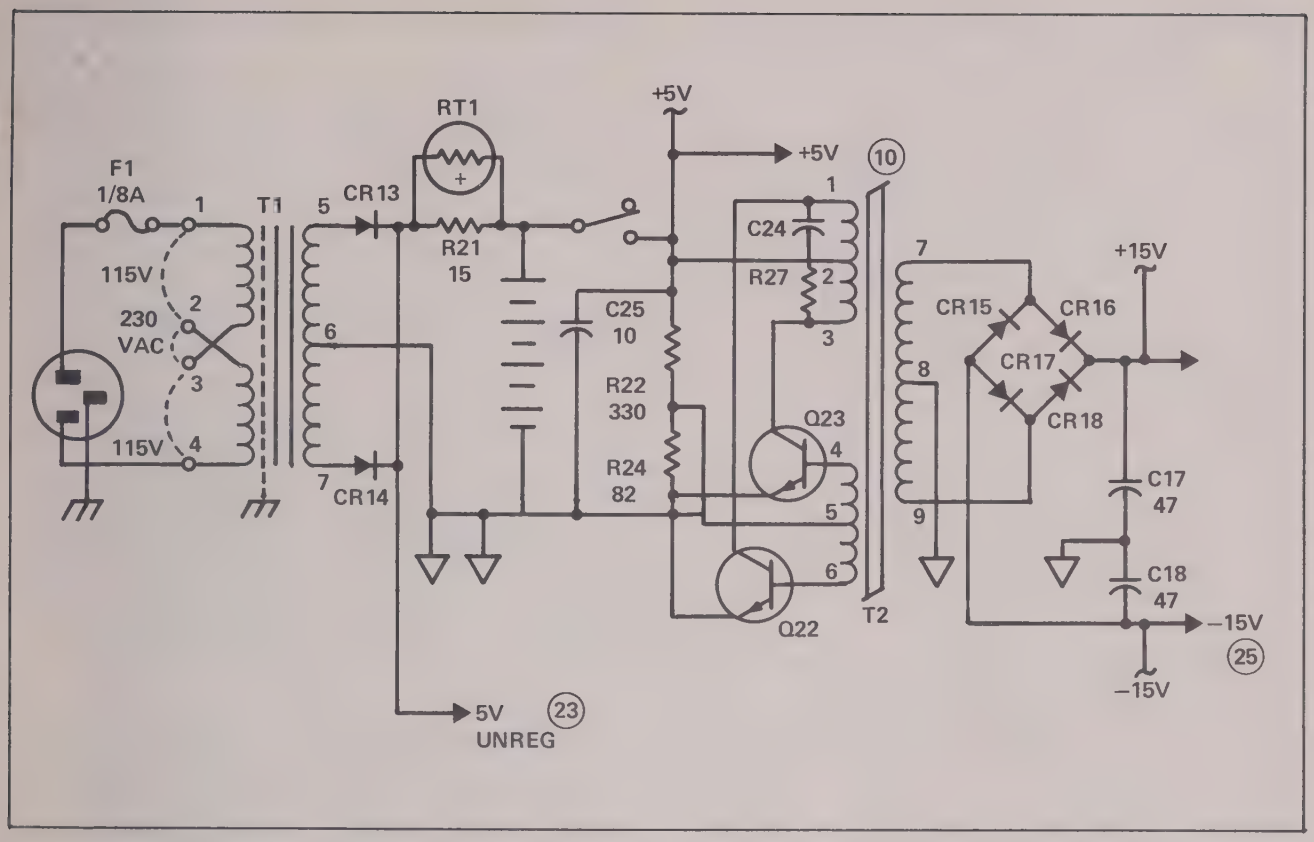


Figure 14. POWER SUPPLY BATTERY OPERATED

BATTERY OPERATED POWER SUPPLY (Fig. 14)

Line power is furnished to transformer T1 whose secondary output is rectified by the full-wave rectifier formed by CR13 and CR14 and is applied through R21 and RT1 which forms the recharging network that will supply 400 mA to the batteries. It should be noted that power switch S12 allows the batteries to recharge even though the instrument power switch is in the OFF position. With the power switch enabled 100 mA is supplied to the batteries and 300 mA is supplied to a 6 kHz inverter. It should be noted that the dc charging voltage is +5 volts and the batteries act as a filter for the +5 volt logic supply as seen on the schematic diagram. The +5 volts is then applied through power switch S12 to the 6 kHz inverter formed by Q22 and Q23. The 6 kHz output is connected to the primaries of transformer T2. The secondary of T2 is applied across a bridge rectifier formed by CR15, CR16, CR17, and CR18. The +15 volt operating supply is filtered by C17 while the –15 volt operating supply is filtered by C18.

NOTES:

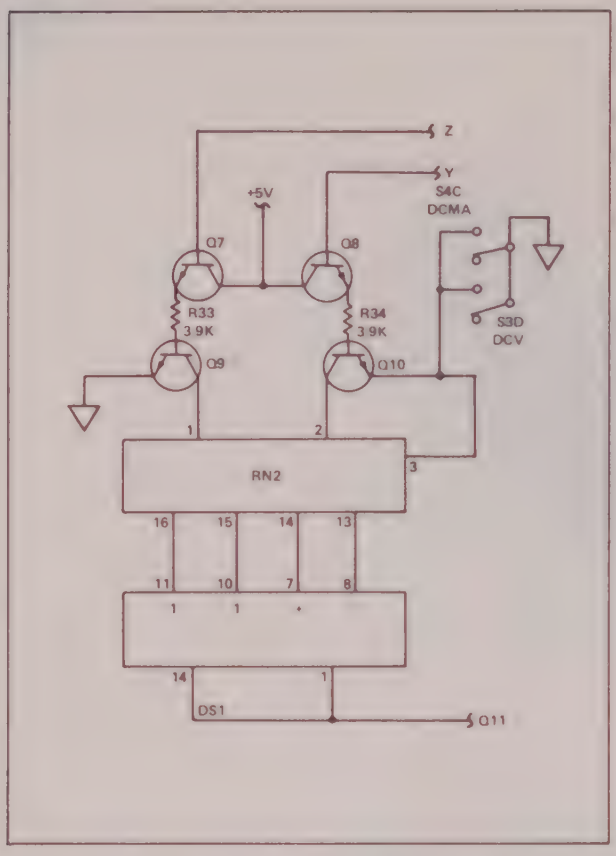


Figure 15. POLARITY AND OVERRANGE

POLARITY AND OVERRANGE (Fig. 15)

Polarity and Overrange information is strobed out of the Digital I.C. during the S1 period on the Y and Z lines. The Y line transmits polarity information while the Z line contains the Overrange information. If the Y line is high (+5V), transistor Q8 will be enabled which will enable transistor Q10. This will cause pin 7 of DS1 to be low thereby lighting the plus sign in DS1. If the Z line is high (+5V), Q7 will be enabled, enabling transistor Q9 thus causing a 1 to be displayed in DS1 during the S1 strobing period only.

DECODER DRIVER (Fig. 16)

BCD output information from the Digital I.C. is applied to the Decoder Driver. The Decoder Driver will furnish a low potential (0 volts) on the proper combination of the W, X, Y, and Z lines to display the number digitized. The BCD count is strobed out by the S2, S3, and S4. Figure 16 is a truth table representing the BCD count from the Decoder Driver.

LIGHT EMITTING DIODES (LED'S) (Fig. 17)

LED's are used as a display element of this instrument. In order for a Light Emitting Diode to illuminate a low potential must be applied to the cathode (0 volts), simultaneous with a high potential (+5 volts) on the

BCD COUNT					DECODER DRIVER OUTPUT LINES						
LINES				BCD COUNT	LINES						
W	X	Y	Z		9	10	11	12	13	14	15
0	0	0	1	1	–	–	X	X	–	–	–
0	0	1	0	2	X	X	–	X	X	X	–
0	0	1	1	3	–	X	X	X	X	X	–
0	1	0	0	4	–	–	X	X	–	X	X
0	1	0	1	5	–	X	X	–	X	X	X
0	1	1	0	6	X	X	X	–	–	X	X
0	1	1	1	7	–	–	X	X	X	–	–
1	0	0	0	8	X	X	X	X	X	X	X
1	0	0	1	9	–	–	X	X	X	X	X

NOTE: X = LOW LEVEL

Figure 16. DECODER DRIVER

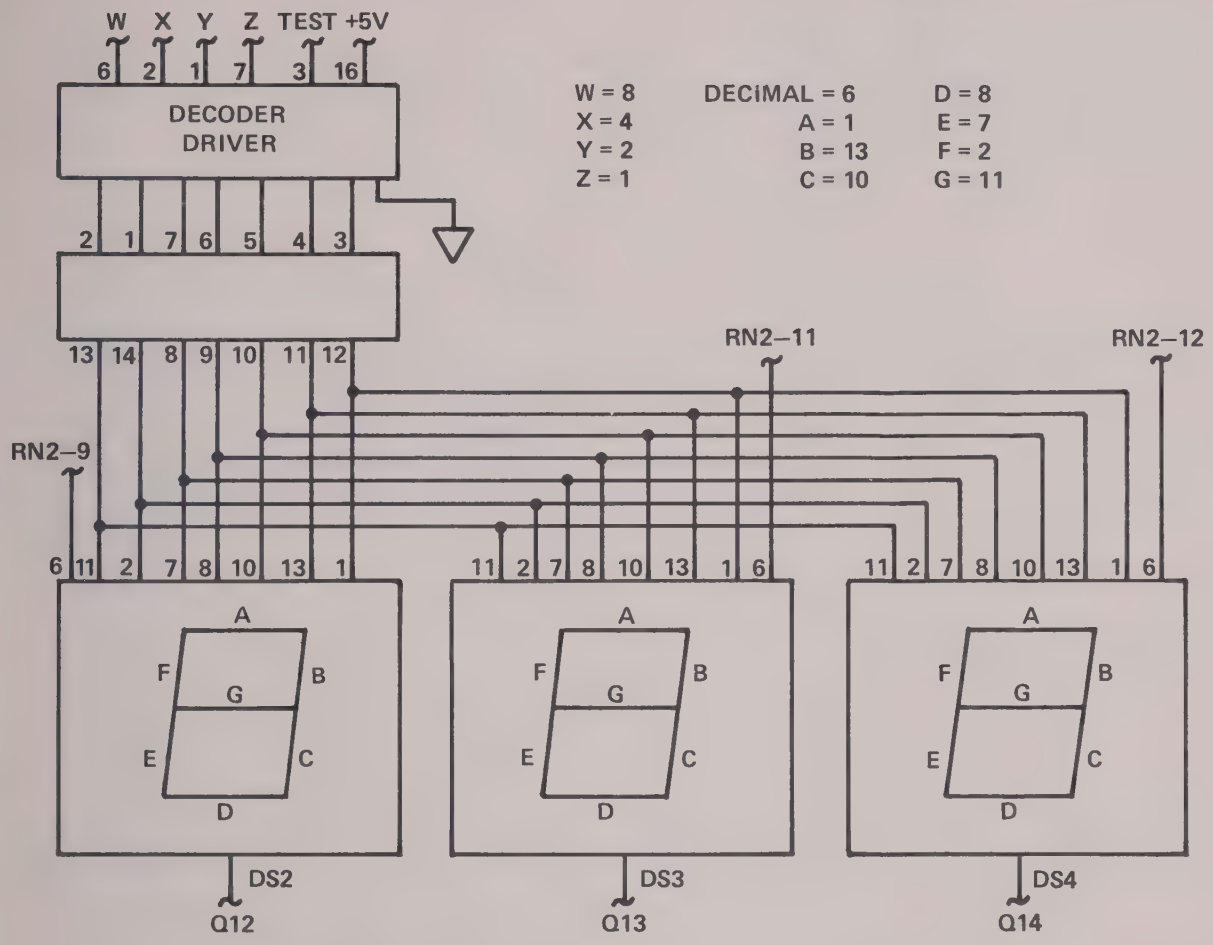


Figure 17. DECODER DRIVER AND LEDS

anode. The low potential in the case of the 8000 is commanded by the Decoder Driver in accordance with the BCD count as shown in Figure 16. The high potential applied to the anode is commanded by the strobing pulses S1, S2, S3, and S4 from the Strobing Circuit. The sequence of display is such that the DS1 lights first, the DS3 lights second, the DS2 lights third, and the DS4 lights last.

NOTES:

STROBING (Fig. 18)

Transistors Q11 through Q18 supply the strobing pulses. A high potential on the base of transistor Q15 will enable that transistor causing Q11 to be enabled. This will apply a high potential (+5 volts) to DS1. The remaining strobing circuits operate in the same manner to illuminate LED's DS2, DS3, and DS4.

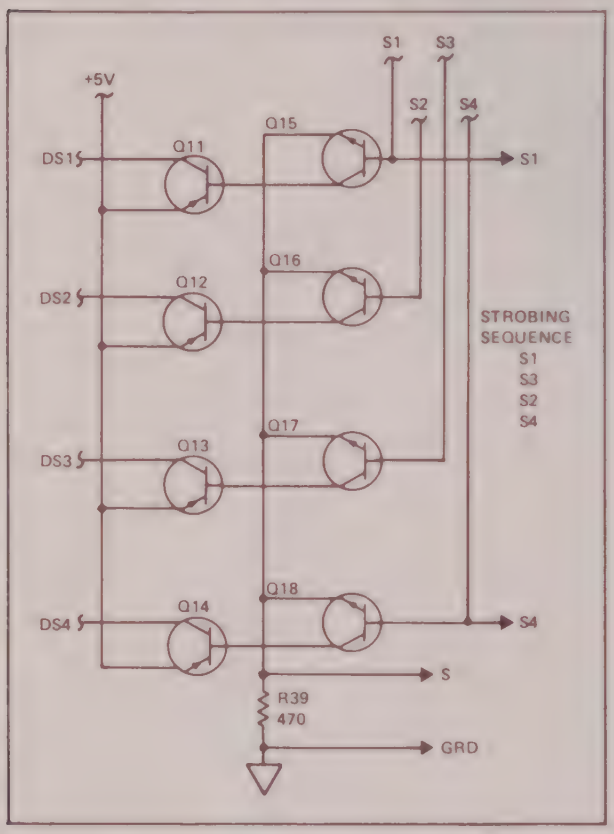
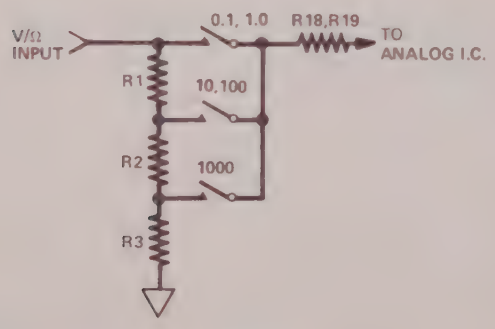


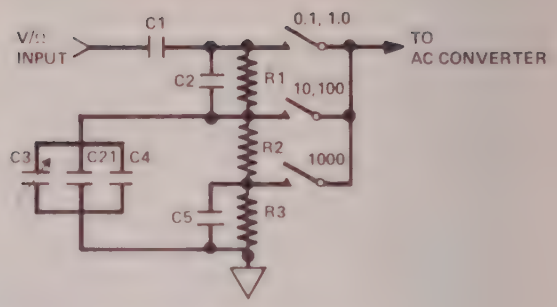
Figure 18. STROBING CIRCUIT

INPUT SECTION



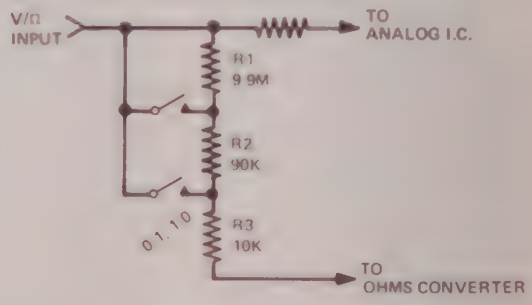
DCV CONFIGURATION

In the DCV function the Input Divider attenuates the input voltage to within one of the two ranges (0 to ±0.2 volts or 0 to ±2 volts). Resistors R1, R2, R3 and the Range Switch are shown that make up the Input Divider in the DCV function. The output of the divider in this configuration is fed directly to the Active Filter.



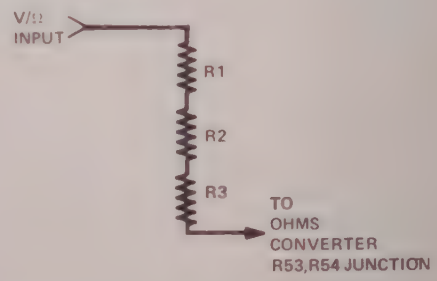
AC VOLT CONFIGURATION

The Input Divider in this function contains the same resistors plus capacitors C1, C2, C3, C4, and C21, which are added to linearize the ac measurements. The attenuated ac is applied through switch S1B to the gate Q1 which is the input to the ac converter. The output of the ac converter is applied through switch S1D to the Active Filter before being applied to the Analog I.C.



KILOHMS CONFIGURATION

In this function, the low end of the Input Divider is removed from ground and connected to the output leg of the Ohms Converter Amplifier through switch S5B. Q2 is connected to CL1 and Q3 in such a manner as to cause 1.0 mA of current to flow. This furnishes the potential across the Input Divider string for resistance measurements.



20 MEGOHMS CONFIGURATION

With the 20 MΩ function selected, the output of the ohms converter is fed through switch S6C to the bottom of the input divider. Once again, Q2 requiring 1.0 mA flow causing a current to be supplied to the Input Divider for measuring in the 20 MΩ range.

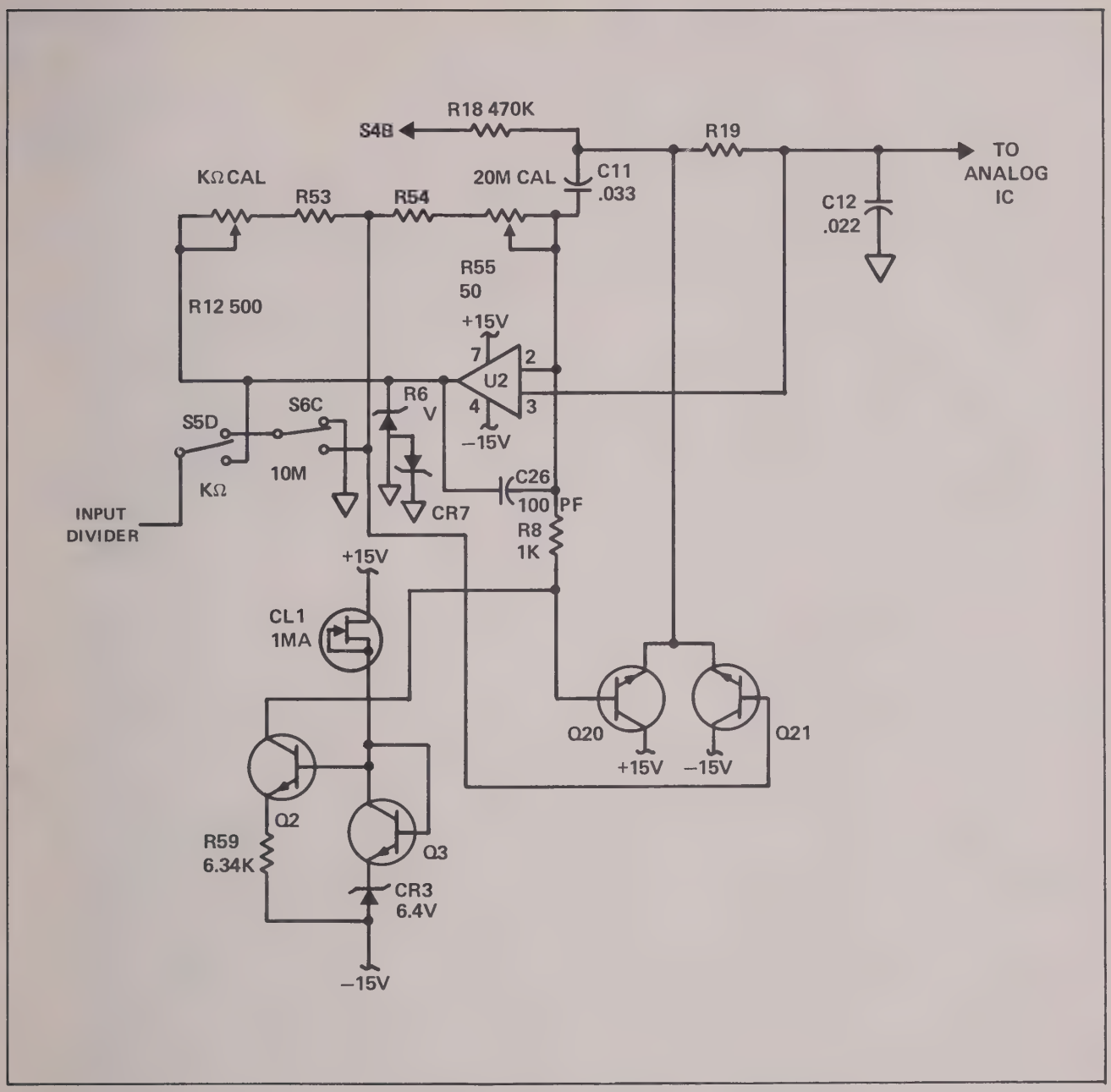


Figure 19. OHMS CONVERTER/ACTIVE FILTER

ACTIVE FILTER (Fig. 19)

The Active Filter is a two pole filter. One pole being comprised of R18 and C11, the other pole is comprised of R19 and C12. Amplifier U2 senses the noise on the input line and feeds back a signal equal, but, out of phase with the input to cancel ac and transient components. Transistors Q20 and Q21 furnish over load protection on the input line to the Analog I.C.

OHMS CONVERTER (Fig. 19)

When an ohms function is selected, kilohms or megohms, the low end of the Input Divider is applied to the Active Filter circuitry, thus enabling the Active Filter in ohms functions. Figure 19 shows the configuration of the Active Filter circuitry when used in the ohms function. The Input Divider and the unknown resistor form a variable divider network on the output leg of Amplifier U2. The output of the amplifier supplies 1 mA of current back to a current source (Q2) and a small amount of current through the divider network. The voltage at the junction of the Input Divider and the unknown resistance will be within one of the two basic ranges of the instrument. It is this voltage that is fed to the Analog I.C. for measurement and is a representative of the resistance being measured.

OHMS OVERRANGE VOLTAGE LIMIT (Fig. 20)

The open circuit ohms voltage is nominally 15 volts dc. When the ohms limit circuit is installed, the open circuit voltage is limited to less than 5 volts dc. The components required to accomplish this are CR7, CR21, Q4, Q5, R28, R29, and R31. If the non-inverting input to ohms converter, U2-3, rises above 2.8V dc, because of an overrange or open-circuit condition, Q5 conducts. This condition causes Q4 to conduct and bypass current around the inverting input of the ohms converter a U2-2 to limit the output of U2 to 5V dc or less.

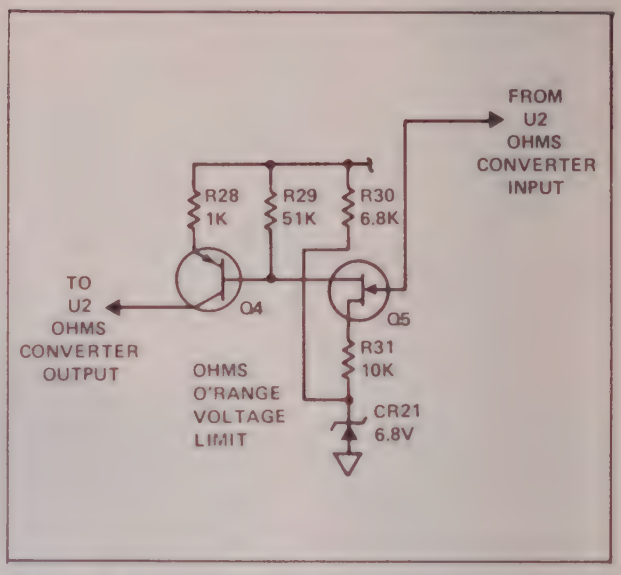


Figure 20. OHMS OVERRANGE VOLTAGE LIMIT

AC CONVERTER (Fig. 21)

All ac to be measured is applied through the ac converter. This converter consists of a FET voltage follower, Q1 feeding an Operational Rectifier consisting of amplifier U1, CR4, and CR5. The input signal is buffered by Q1 and fed to the non-inverting terminal of Amplifier U1. The negative feedback through diodes

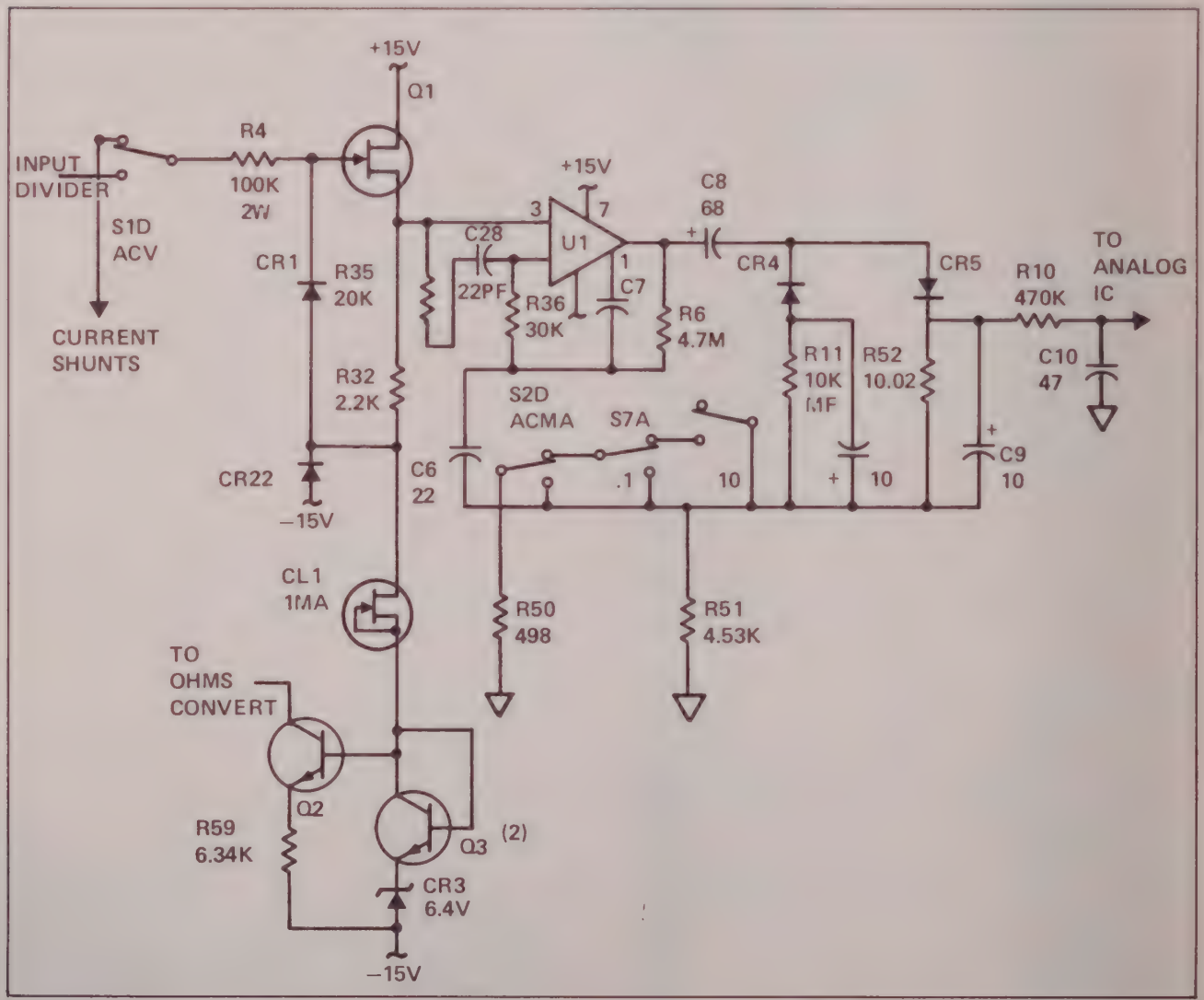


Figure 21. AC CONVERTER

CR4 and CR5 forces the same voltage to appear at the inverting terminal of U1 causing a current flow through R51 to ground. This current flows through the diodes on alternate half cycles causing half the average current to flow through R52. The voltage developed across R52 is filtered and fed to the active filter, then to the input of the Analog I.C. The conversion gain can be changed by changing the feedback resistance value.

NOTES:

CALIBRATION (Figure 22A through 22F)

By following the steps A through F shown in Figure 22 complete calibration of the 8000 can be accomplished.

FUNCTION
DCV, ACV

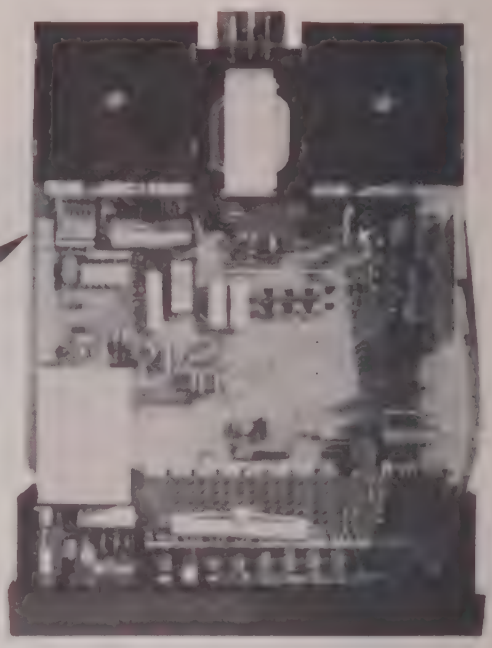
RANGE
2, 20, 200, 2000

INPUT
0 VOLT

ADJUSTMENT
PERIOD (R20)

COUNTER CONNECTION
TP5

COUNTER READOUT
100,000 μsec



FUNCTION
DCV

RANGE
200mv

INPUT
+ 0.19V dc

ADJUSTMENT
200 MVDC (R23)

DISPLAY
+190.0

Figure 22. CALIBRATION (Sheet 1 of 3)

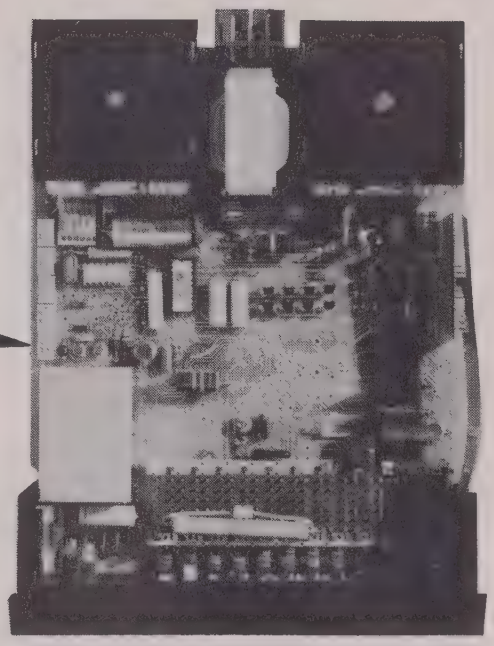
FUNCTION
DCV

RANGE
2

INPUT
+1.9V dc

ADJUSTMENT
2 VDC (R25)

DISPLAY
+1.900



FUNCTION
ACV

RANGE
20

INPUT
19Vac @20kHz

ADJUSTMENT
HF ADJ (C3)

DISPLAY
19.00

Figure 22. CALIBRATION (Sheet 2 of 3)

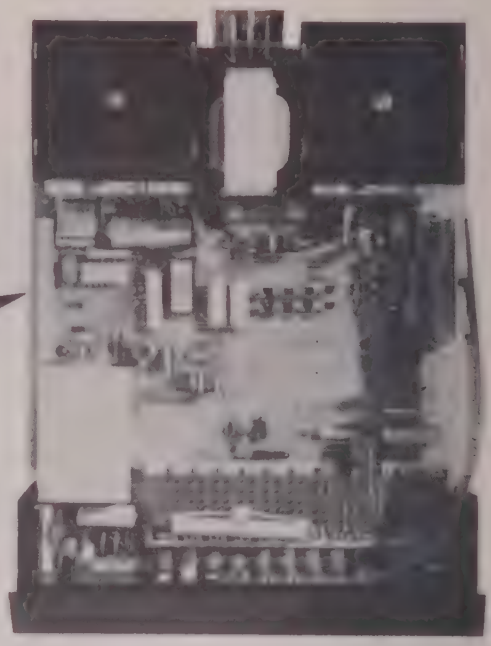
FUNCTION
KΩ

RANGE
20

INPUT
19KΩ

ADJUSTMENT
KOHM (R12)

DISPLAY
19.00



FUNCTION
20 MΩ

RANGE
NONE SELECTED

INPUT
19MΩ

ADJUSTMENT
20M (R55)

DISPLAY
19.00

Figure 22. CALIBRATION (Sheet 3 of 3)

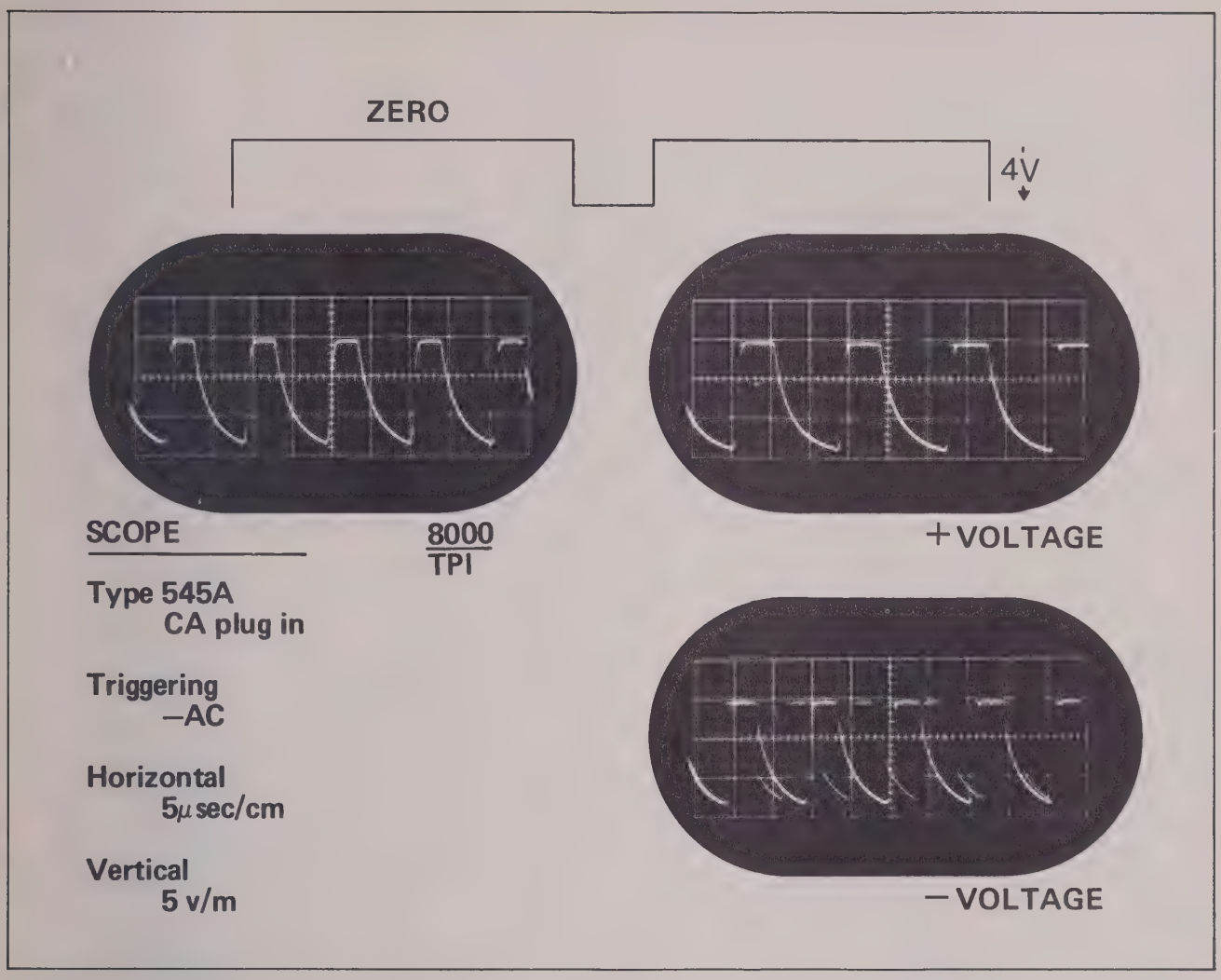
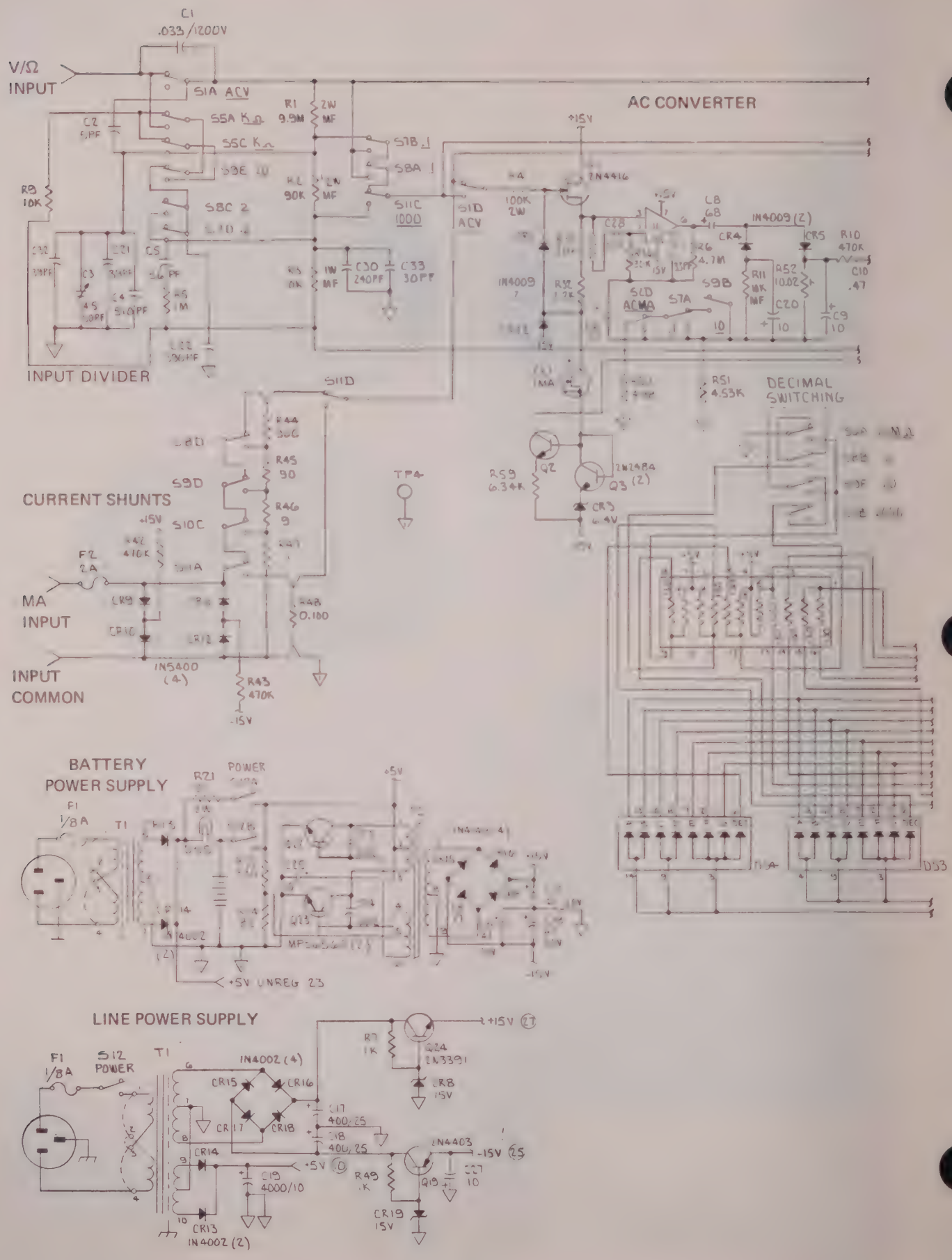


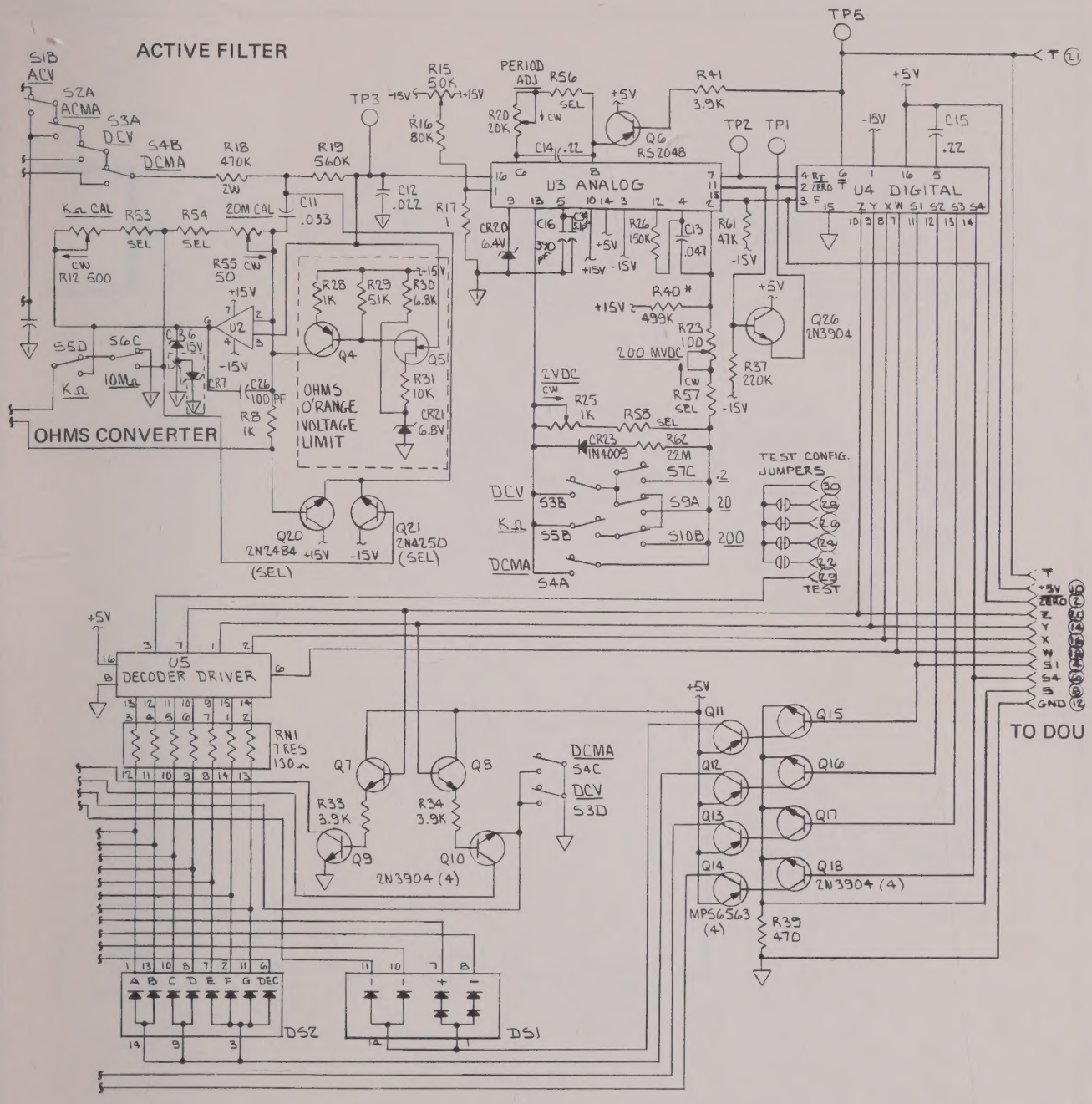
Figure 23.

TROUBLESHOOTING

As with any other digital instrument the best approach to efficient and effective troubleshooting is a careful analysis of apparent malfunctions. First, by observing the display and then checking each function. Other keys to troubleshooting are the waveforms out of the Analog I.C. They should appear as shown in Figure 23. A troubleshooting analysis chart can be found on Figure 24.

NOTES:


V/Ω INPUT
INPUT DIVIDER
AC CONVERTER
CURRENT SHUNTS
MA INPUT
INPUT COMMON
DECIMAL SWITCHING
BATTERY POWER SUPPLY
LINE POWER SUPPLY
+5V UNREG 23
+15V
-15V
+5V
IN4002 (4)
IN4002 (2)
IN4009 (2)
IN4009
IN4403
2N4416
2N2484
IN5400 (4)



8000A DIGITAL MULTIMETER
SCHEMATIC DIAGRAM

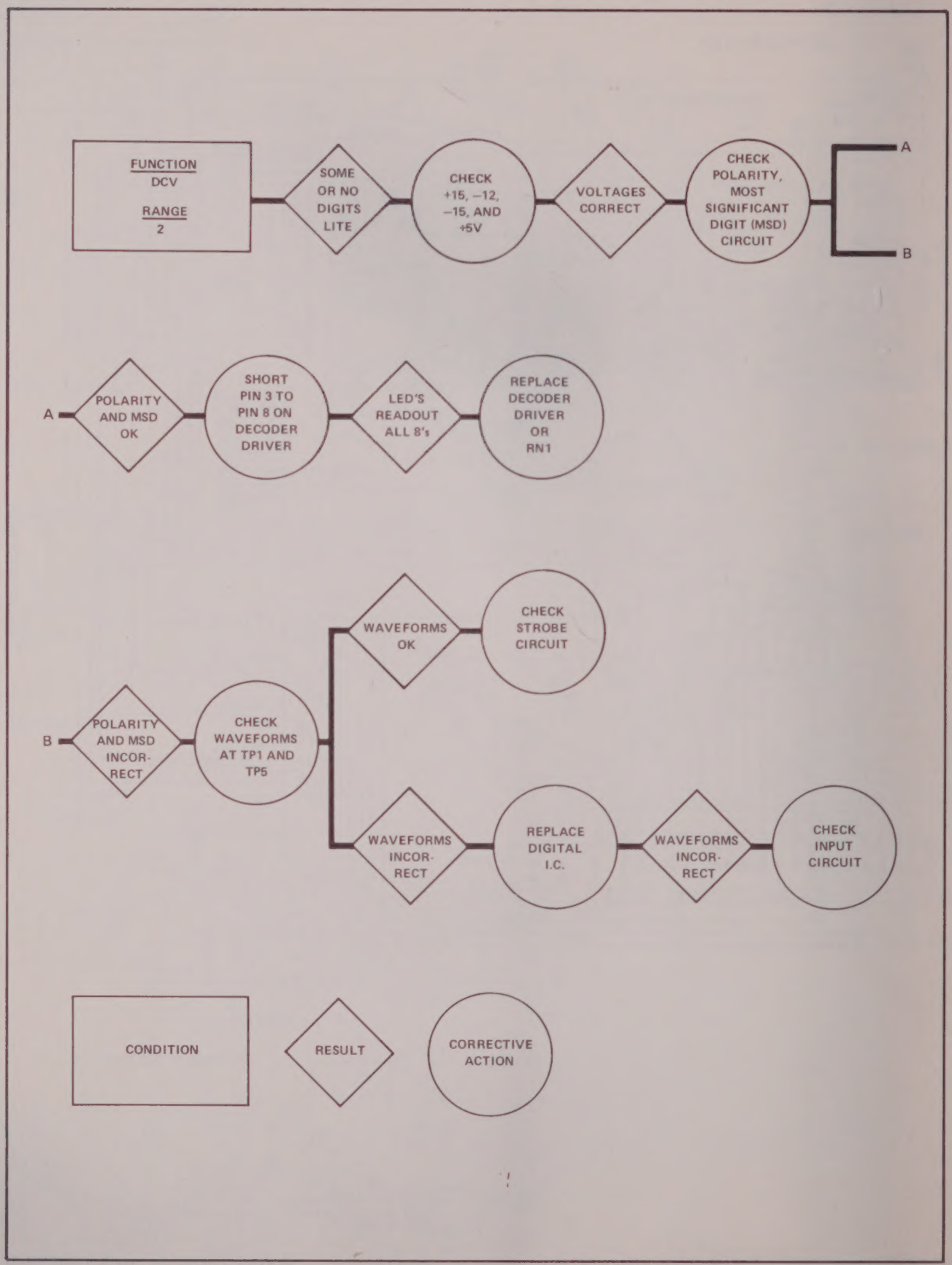
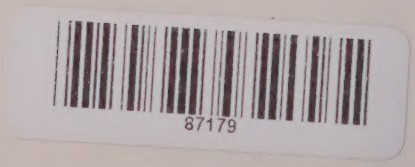


Figure 24. TROUBLESHOOTING CHART


87179